SECOND INTERIM TECHNICAL REPORT

For The

STUDY ON INTEGRATION OF SILVER-ZINC BATTERY IMPROVEMENTS

(1 November 1968 – 28 February 1969)

Contract No.: NAS 5-11579

GODDARD SPACE FLIGHT CENTER
Contracting Officer: J.C. Comstock
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Hughes Ref. No. B6700 · SSD 90105R

ABSTRACT

This report covers the second 4-month period of Contract No. NAS 5-11579. The object of this program is to design a lightweight, experimental, five-cell, 12 amp-hr, silver-zinc battery for space application that incorporates many technology and design improvements for the purpose of achieving better cycle life and performance.

The current battery fabrication status is reported, along with additional information on the methods that will be used to incorporate the many separately developed silver-zinc technology improvements into the batteries for this program. A complete battery fabrication logic chart, and a drawing and specification package are contained in this report.

CONTENTS

ILLUSTRATIONS

TABLE

1.0 INTRODUCTION

This report covers the second 4-month period of activity on this contract. In general, this program has three main objectives:

1) The integration of Government-sponsored silver-zinc battery improvements along with Hughes aerospace packaging concepts to enhance the performance of the silver-zinc battery system for space applications.

2) The reduction of battery package weight by 20 to 30 percent compared to state-of-the-art batteries utilizing individual cells and associated hardware.

3) The design, fabrication, and delivery of six, five-cell 12 amp-hr, nonmagnetic, experimental silver-zinc batteries to NASA-GSFC.

Many Government-sponsored technology contracts over the last 3 to 4 years have led to specific improvements in the silver-zinc system. However, while improved components (i.e., plates, separators, and seals) have been developed on independent programs, there has been little effort made to incorporate several of these improvements into one silver-zinc battery. The purpose of this program is to combine several independently developed improvements, along with lighter weight aerospace packaging, into one battery designed for optimum performance.

During this reporting period, the battery design, developed during the last reporting period, was documented with the drawings and specifications included in Appendix I and II, respectively, of this report. Also, orders have been placed for all major and most minor component parts of the battery assembly. A fabrication logic chart is presented that illustrates the complete manufacturing sequence to be used for this 12 amp-hr battery assembly.

A core shifting problem has been encountered in injection molding the five-cell monoblock case. However, it is not considered to be insolvable. Details are reported in Section 2.1.1. There has been some slippage in the delivery schedule for the silver and zinc oxide plates from ESB, Inc., but a firm delivery date will be negotiated shortly.

In retrospect, perhaps the battery design developed during this contract is more complex than anticipated; but this degree of complexity is necessary to permit a valid comparison of the cumulative improvements, such as:

1) Elimination of U-fold

2) Microfuel cell

3) Improved separator system

4) Use of common gas manifold

5) Use of nearly draft angle-free cell jar

6) Lightweight packaging incorporated in battery design

It should be noted that this battery is designed as a test vehicle built to space environmental requirements. If this battery design should demonstrate superior performance characteristics during the planned test programs, particularly regarding wet stand and cycle life, then the design can readily be upgraded to flight battery status. If the design goal of 3 years in synchronous orbit* is achieved by laboratory testing of these batteries, there will be no question concerning the need for the salient features of this battery for all future silver-zinc space batteries.

In brief, the main effort during this 4-month reporting period was directed toward 1) documentation of the design developed during the first reporting period (see Appendices I and II) and 2) initiation of the fabrication of battery parts.

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*Synchronous orbit for test purposes is defined as 90 charge/discharge cycles per year composed of a 23-hour charge period followed by a 1-hour discharge period.

2.0 TECHNICAL DISCUSSION

2.1 PACKAGE PARTS

2.1.1 Battery Case

Two attempts have been made by Jupiter Engineering to injection mold the five-cell battery case, P/N 3182793. These trial runs have been made using SAN (styrene acrylonitrile) because of its transparency rather than with the Noryl (styrene-polyphenylene oxide alloy) that will be used for the actual battery case. The Noryl 731-701 is an opaque material.

The cases produced during the first two trial runs indicated that there is no problem in filling a wall approximately 4.5 inches high by 0.080 to 0.110 inch thick. This had been a major concern. However, the main problem experienced with the first two cases was core shifting. This core shifting probably is caused by inadequate support of the cores at the baseplate, combined with the use of a single sprue directly over the center core.

A third SAN case was molded following modification of the tooling to include two 0.0625-inch diameter pilot pins for each of the five cores. These pins were located in the mold base and mated with the cores upon closure. Unfortunately, these pins sheared apart during this third run permitting the cores to shift apart again. Several possible solutions are under study to correct this problem. It should be understood that the tooling for this battery case was fabricated at minimum cost because of the limited number of cases required for this contract; but, in addition, the requirement for a nearly draft angle-free cell jar definitely is pushing the state of the art for multi-cavity injection molds. Further modification of this tooling will be accomplished within the cost structure dictated by the need for only six or eight cases rather than for a larger quantity.

A copy of the latest case drawing, 3182793, is included in Appendix I of this report for reference.

2.1.2 Battery Cover

The battery cover, P/N X3182729, will be machined rather than injection molded because of the limited number of covers required and the high cost associated with the development of the injection mold tooling. Should it subsequently be necessary to manufacture a larger quantity of batteries for use on a satellite program, injection molded covers would be required because of the unknown increase in the degree of surface stresses produced by a machining operation. The covers for this program will be annealed after machining to minimize the probability of stress cracking.

The battery cover is perhaps the most important part of the battery packaging because it directly interfaces with the following other components:

1) Battery case

2) Plate tabs

3) Cell interconnects

4) Manifold lid

5) Connector

6) Microfuel cell assembly

7) Semipermeable membranes

8) Wiring, etc.

A purchase order has been placed with Real Art Plastic Company, Los Angeles, for machined battery covers and manifold lids. Delivery is scheduled for 7 April 1969.

2.1.3 Separator Frames

Teksun Incorporated, Los Angeles, has completed delivery of both the positive and negative plate separator frames. Hughes Quality Control has measured these frames and found them in conformance to Drawing X3182856. A copy of this drawing is included in Appendix I.

Several injection molding companies considered this to be an impossible job from the standpoint that the notch required for the silver plate tabs permitted only 0.010-inch thick Noryl at that point. Further, the frames themselves were very thin, i.e., 0.021 and 0.029 inch thick. Teksun accomplished this job by use of multiple gates, and, in particular, with the use of gates directly into the thin notch areas of the frames. Figure 1 is a photograph of two separator frames, along with a complete tree showing the multiple gate configuration required to produce these parts.

2.1.4 Manifold Cover

The manifold cover is currently being machined by Real Art Plastic Company. Refer to the comments in Section 2.1.2 for further information. A copy of Drawing X3182883 is included in Appendix I for reference. This is a simple part to machine, so no problems are anticipated.

2.2 ELECTRICAL BUS AND INSTRUMENTATION CONNECTIONS

2.2.1 Bus Interconnects

The OFHC copper interconnects serve two purposes. First, they collect the tabs from all positive or negative plates in one cell, and thus serve as a lightweight collector comb or terminal. Second, the interconnects already providing the function of an intracell connector also provide the intercell series connections for the five-cell battery. These bus interconnects are described in Drawings X3128884 and X3128885, included in Appendix I. These parts are currently being machined within Hughes.

2.2.2 Instrumentation Wiring

Voltage instrumentation leads will be brought out from the appropriate interconnects to the connector to provide a means for monitoring individual cell voltages during battery operation. Because the interconnects will be potted in epoxy, the instrumentation wires must be routed and wired in place during battery fabrication. Instrumentation and microfuel cell wiring will be nonredundant for these experimental batteries. However, if batteries of this type were actually required for a space flight mission, additional connector pins and redundant instrumentation wiring would be necessary for reliability.

2.2.3 Connector

ITT Cannon connectors, P/N DBM 255-NMC-2-A134, were supplied as Government-furnished equipment to Hughes. The inserts and hardware of these connectors are non-magnetic. The pin selection is shown in Figure 2.

2.3 ELECTROCHEMICAL

2.3.1 Plates

A purchase order has been placed with ESB, Inc. for the silver and zinc oxide plates. The silver plate must meet the requirements of Drawing X3182870 and Procurement Specification XPS 30929-016, Revision B. Similarly, the zinc oxide plate must meet the requirements of Drawing X3182871 and Procurement Specification XPS 30929-017, Revision B. These documents are included in the appendices for reference.

A detailed description of plate sizing was included in the First Interim Technical Report for this contract.

2.3.2 Separator System

The separator system consists of two or three components depending upon optional cell configuration. The separator system will contain one layer of absorber on each side of the positive plates, four or five layers of RAI

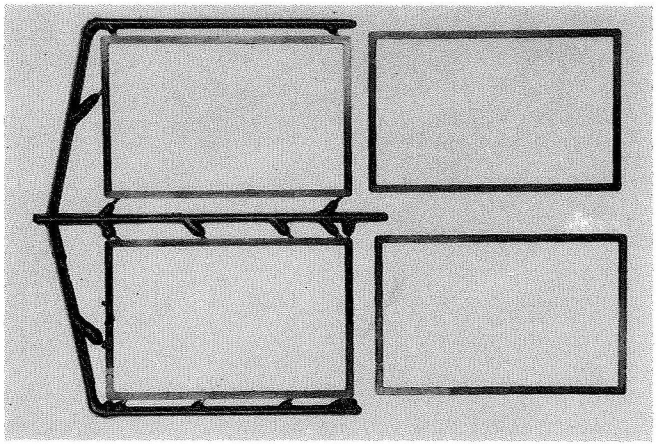


Figure 1. Separator Frames and Tree From Injection Mold (Photo ES 23296)

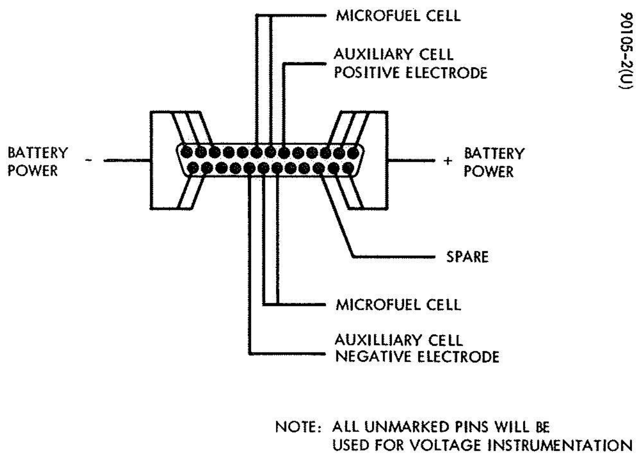


Figure 2. Connector Pin Utilization

Permion 2290 separator, and will incorporate 0.0013-inch thick calcium hydroxide electrodeposited on the silver plates in three of the six batteries. The separator system choices and optional configurations are summarized in Table I.

TABLE I. SEPARATOR SYSTEM CONFIGURATION

Component	Option 1	Option 2
Absorber: 1) Pellon 2506K or 2) Kendall Webril M1405	One layer, 0.001-inch thick	One layer, 0.001-inch thick
Separator: RAI Permion 2290	Five layers, each 0.0013-inch thick	Four layers, each 0.0013-inch thick
Positive plate silver migration barriers: Electrodeposited calcium hydroxide	None	One layer, 0.0013-inch thick on silver plate

2.3.3 Electrolyte

Because maximum cycle life is required for the batteries to be built on this program, the electrolyte will be 40 percent by weight potassium hydroxide solution that is 90 percent by weight saturated with zinc oxide. The computed theoretical ampere-hour negative-to-positive ratio of 1.7 was reported in the previous Interim Technical Report. Saturation of the electrolyte with zinc oxide will inhibit the solution of zinc oxide from the negative plates and therefore will help to maintain the high negative-to-positive capacity ratio throughout the cycle life of the battery.

2.4 PROCESSES

2.4.1 Calcium Hydroxide Electroplating

Three of the six batteries that will be fabricated on this contract will contain 0.0013-inch thick electrodeposited calcium hydroxide on all silver plates. This General Electric process was developed to evaluate the effect that various thicknesses of calcium hydroxide would have in reducing the rate of silver migration through the separator system of a silver-zinc or silver-cadmium cell, and to evaluate the ability of calcium hydroxide coating to block or blunt zinc dendrite formation. Its use on this contract is to inhibit silver migration through the RAI Permion 2290 separator system.

Several improvements in the calcium hydroxide process have been accomplished at Hughes. Primarily, the process has been converted to a production technique utilizing a rectangular plating tank that accommodates three to six silver plates at one time. The plating tank, associated hardware, power supply, and instrumentation currently in use are shown in Figures 3 and 4.

The use of the 18 by 12 by 12 inch tank, much greater anode-to-cathode ratio, an activation bath rather than the charge/discharge procedure recommended by General Electric, and greater separation between the silver plates and anodes during plating produces significantly improved calcium hydroxide coatings. Adherence, hardness, thickness uniformity, and edge coating are measurably improved. Typical coating thickness variation of a single plate is ±0.0002 inch. The typical coating thickness variation among the six silver plates from one plating lot is ±0.0003 inch. The mean thickness is reproducible to ±0.0001 inch.

2.4.2 Epoxy Bonding

Because major package parts of the batteries for this contract will be epoxy bonded together, some comments are in order. First, the battery cover self-locates within the battery case, as does the manifold lid into the battery cover. These self-locating features add to the reliability of the epoxy joints. Any bond that can be made without heat-sensitive components, such as the separator and semipermeable membranes in place, will be oven cured. Otherwise, room temperature curing of the epoxy will be used. The epoxy system was thoroughly described in the First Interim Technical Report for this contract.

2.5 BATTERY FABRICATION PLANS

2.5.1 Fabrication Logic

In order to efficiently build an article of the complexity of this battery, it is necessary to summarize the fabrication sequence in a logic chart. It is felt that a chart of this type is far more explanatory than several pages of written information. Therefore, Figure 5, Drawing 3182888, graphically describes the complete manufacturing sequence for this battery.

2.5.2 Bonding Fixture

A bonding fixture is currently being designed that will hold pairs of separator frames, separator (four or five layers), and one layer of absorber material in place for epoxy bonding of this subassembly. Further, fixturing is required to hold the frames pairs and electrodes in place for the second epoxy bonding step required to complete the cell core. Refer to Figure 5, subassembly 1, and the assembly operation immediately following for the sequence of events necessary to complete the cell core assembly.

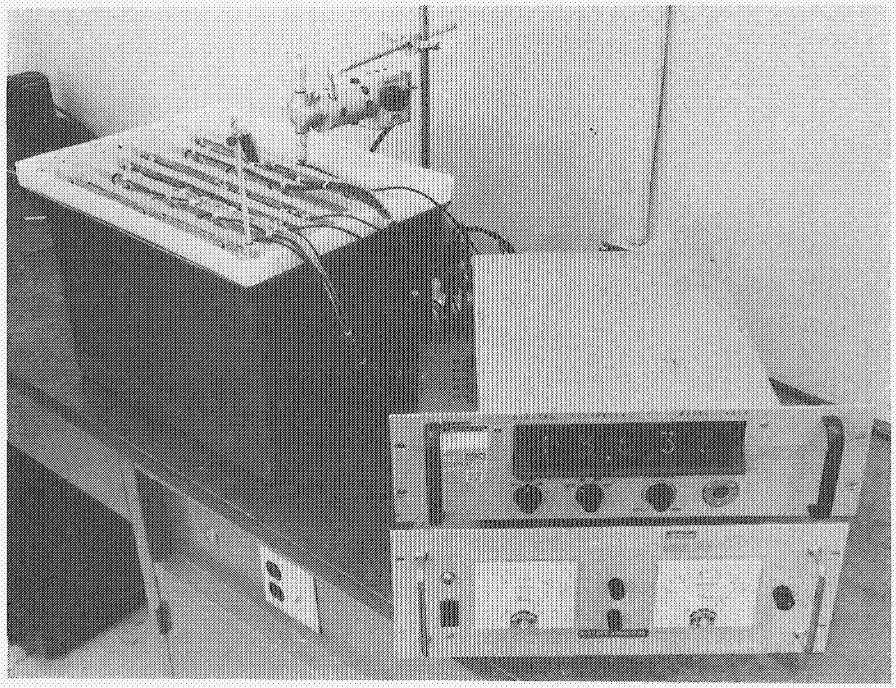


Figure 3. Calcium Hydroxide Electroplating Tank, Power Supply, and Instrumentation

(Photo ES 23530)

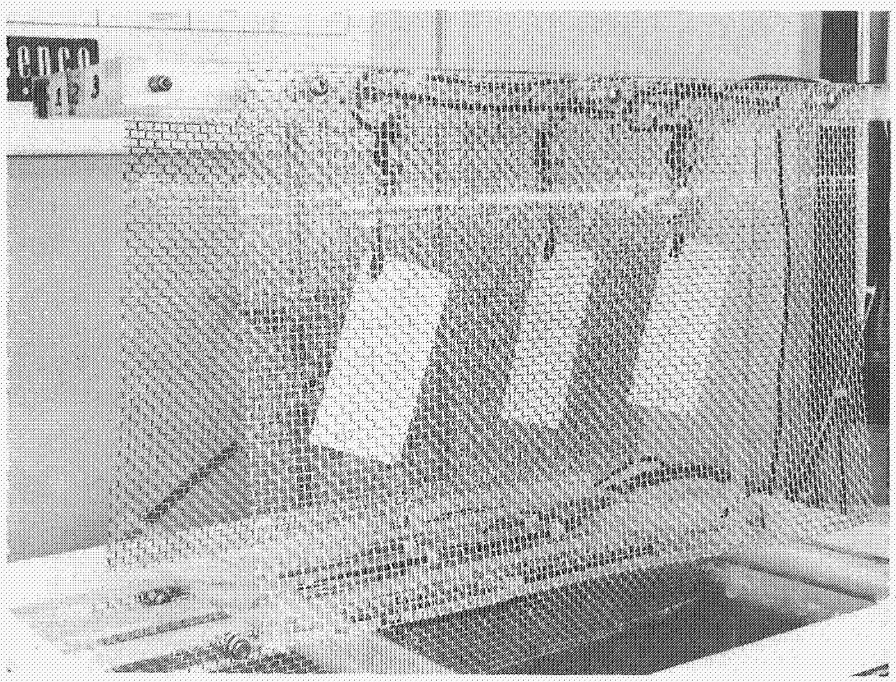


Figure 4. View of Screen Anodes and Silver Plates Used in Calcium Hydroxide Electroplating Bath

(Photo ES 23525)

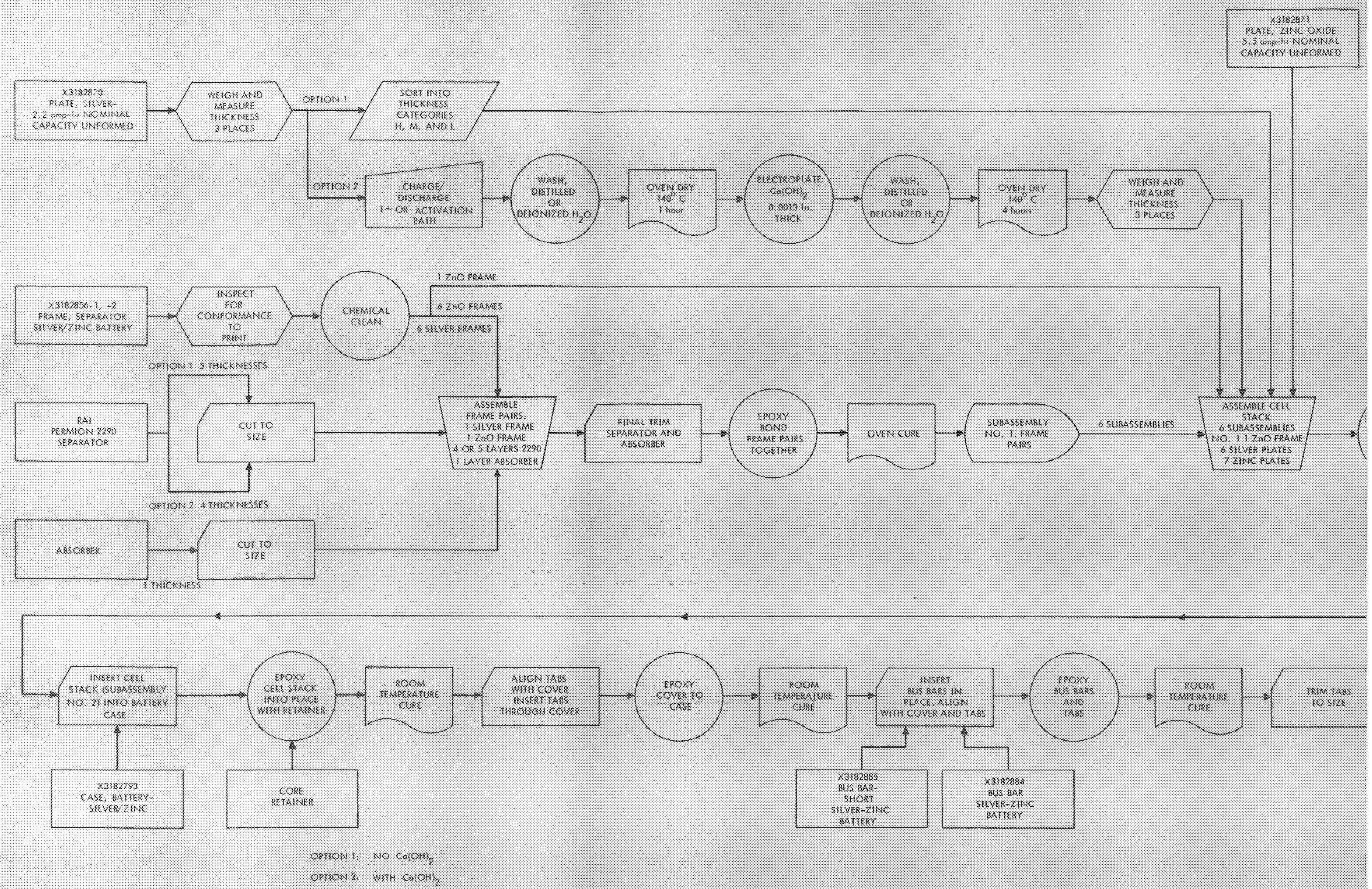
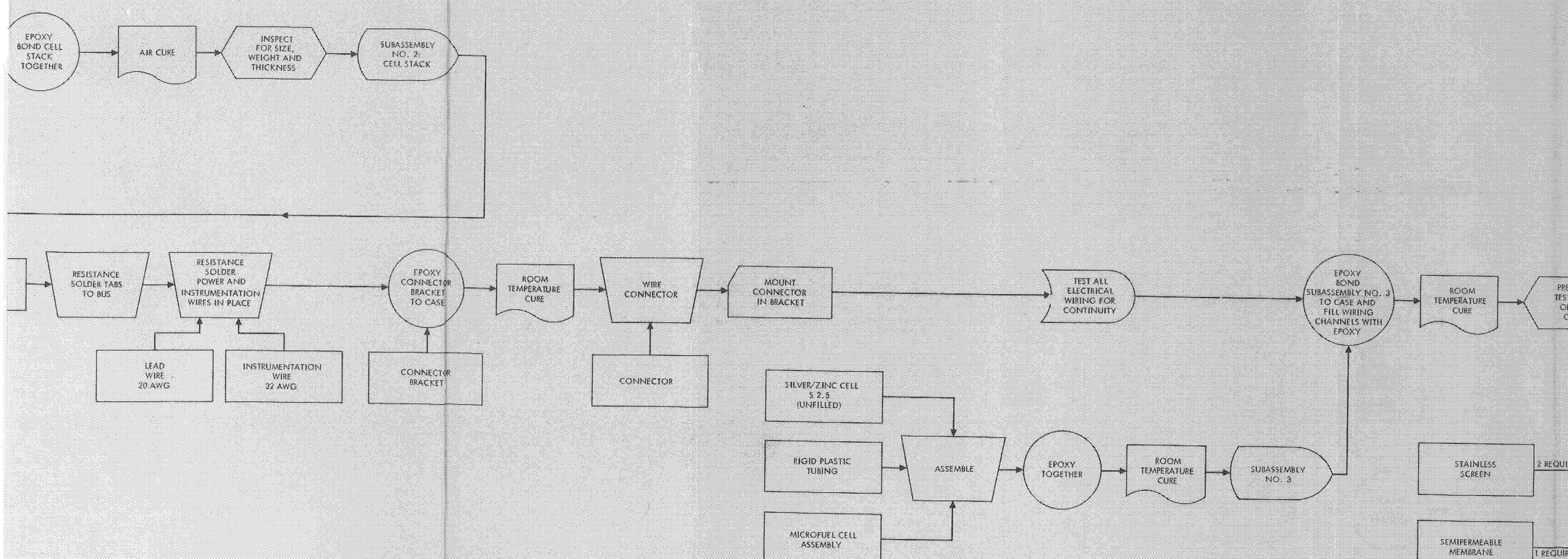


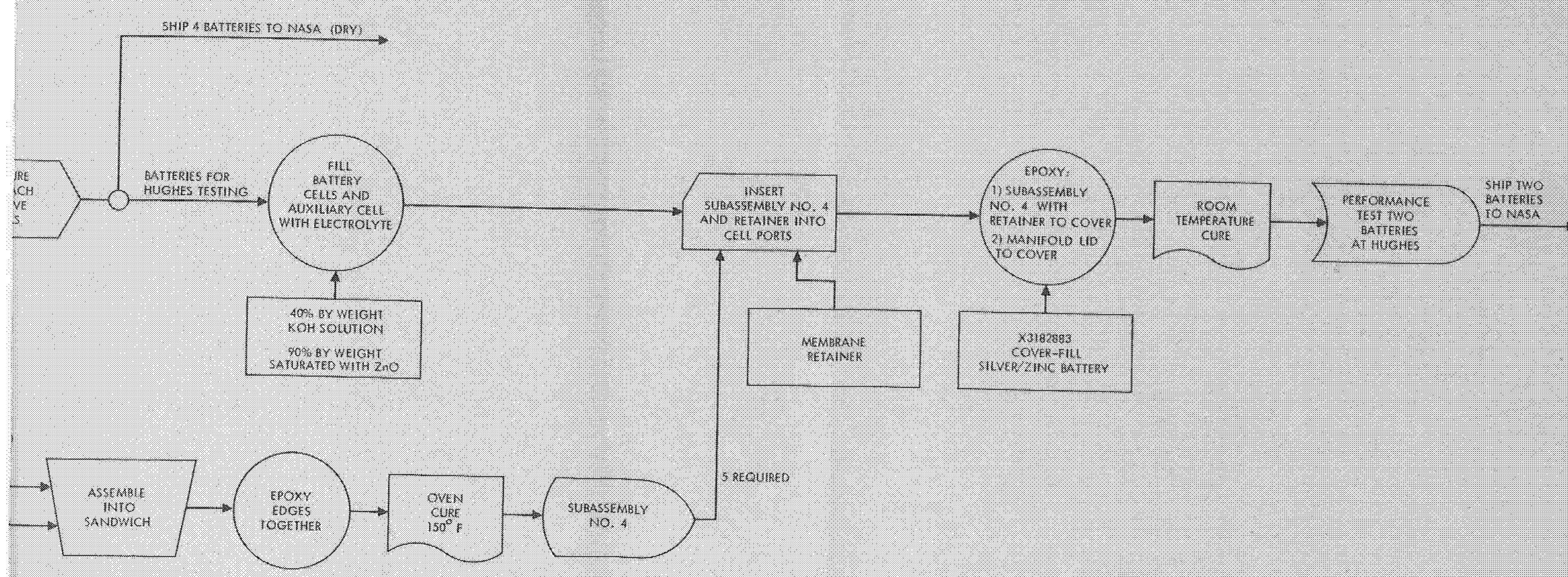
Figure 5. Fabrication Logic for 12 amp-hr, Five-Cell, Silver-Zinc Battery

2



EPOXY BOND CELL STACK TOGETHER
AIR CURE
INSPECT FOR SIZE, WEIGHT AND THICKNESS
SUBASSEMBLY NO. 2: CELL STACK
RESISTANCE SOLDER TABS TO BUS
RESISTANCE SOLDER POWER AND INSTRUMENTATION WIRES IN PLACE
LEAD WIRE 20 AWG
INSTRUMENTATION WIRE 32 AWG
EPOXY CONNECTOR BRACKET TO CASE
CONNECTOR BRACKET
ROOM TEMPERATURE CURE
WIRE CONNECTOR
CONNECTOR
MOUNT CONNECTOR IN BRACKET
TEST ALL ELECTRICAL WIRING FOR CONTINUITY
EPOXY BOND SUBASSEMBLY NO. 3 TO CASE AND FILL WIRING CHANNELS WITH EPOXY
ROOM TEMPERATURE CURE
SILVER/ZINC CELL S 2.5 (UNFILLED)
RIGID PLASTIC TUBING
MICROFUEL CELL ASSEMBLY
ASSEMBLE
EPOXY TOGETHER
ROOM TEMPERATURE CURE
SUBASSEMBLY NO. 3
STAINLESS SCREEN
2 REQUIRED
SEMIPERMEABLE MEMBRANE
1 REQUIRED

3



SHIP 4 BATTERIES TO NASA (DRY)
BATTERIES FOR HUGHES TESTING
FILL BATTERY CELLS AND AUXILIARY CELL WITH ELECTROLYTE
40% BY WEIGHT KOH SOLUTION
90% BY WEIGHT SATURATED WITH ZnO
INSERT SUBASSEMBLY NO. 4 AND RETAINER INTO CELL PORTS
MEMBRANE RETAINER
EPOXY: 1) SUBASSEMBLY NO. 4 WITH RETAINER TO COVER 2) MANIFOLD LID TO COVER
X3182883 COVER-FILL SILVER/ZINC BATTERY
ROOM TEMPERATURE CURE
PERFORMANCE TEST TWO BATTERIES AT HUGHES
SHIP TWO BATTERIES TO NASA
ASSEMBLE INTO SANDWICH
EPOXY EDGES TOGETHER
OVEN CURE 150° F
SUBASSEMBLY NO. 4
5 REQUIRED

2.6 SPECIAL IMPROVEMENTS

2.6.1 Auxiliary Cell

Regardless of the mode of charging, i.e., parasitic or by external means, it is necessary to charge the microfuel cell without producing cell imbalance in the main battery. In the First Interim Technical Report for this program, it was reported that a set of auxiliary electrodes would be used to charge the microfuel cell. This will be done by incorporation of an ESB, Inc. S 2.5 silver-zinc cell that will be attached to the common gas manifold along with the microfuel cell. A wick will be placed between the auxiliary cell and the microfuel cell to produce a common electrolyte path.

Hughes is supplying RAI 2290 separator to ESB for incorporation in these S 2.5 cells. One layer of a 0.001-inch thick unwoven nylon absorber will be used around each positive plate, along with five layers of 2290. A U-fold separator configuration will be used. However, because this auxiliary cell will be charged and discharged at exceedingly low rates, wet stand life should not be sacrificed.

The 2290 separator supplied to ESB is from the same manufacturing lot as that to be used in the 12 amp-hr cells of the battery assembly.

2.6.2 Microfuel Cell

One microfuel cell assembly will be used on each five-cell battery assembly. The primary reason for its use is to recombine excess oxygen gas generated during battery overcharge so that an excessive internal pressure problem does not cause a spontaneous deterioration in battery performance. The Douglas Astropower microfuel cell assemblies will recombine hydrogen as well as oxygen. Appropriate references describing the microfuel cell are listed in the First Interim Technical Report.

Both the microfuel cell and the auxiliary silver-zinc cell required to charge it will be mounted on the five-cell battery case with 3M double-backed tape YO-9122. This tape is a pressure-sensitive high strength neoprene foam 1/32-inch thick that will permit the removal of both the microfuel cell assembly and its associated auxiliary cell should that become desirable following battery fabrication.

Figure 6 shows a Yardney HR16(S)-1 silver-zinc cell with a McDonnell-Douglas microfuel cell assembly bonded to the vent, including a pressure transducer used for the tests that produced the data reported in Figures 6, 7, and 8 of the First Interim Technical Report for this program.

2.6.3 Semipermeable Membrane

A filter holder has been received that will permit testing of several materials for their oxygen gas diffusion rates. The best semipermeable membrane, as characterized by the test results, will be inserted into each of the five cell ports to permit gas flow, but not liquid flow, between individual cells and the common gas manifold.

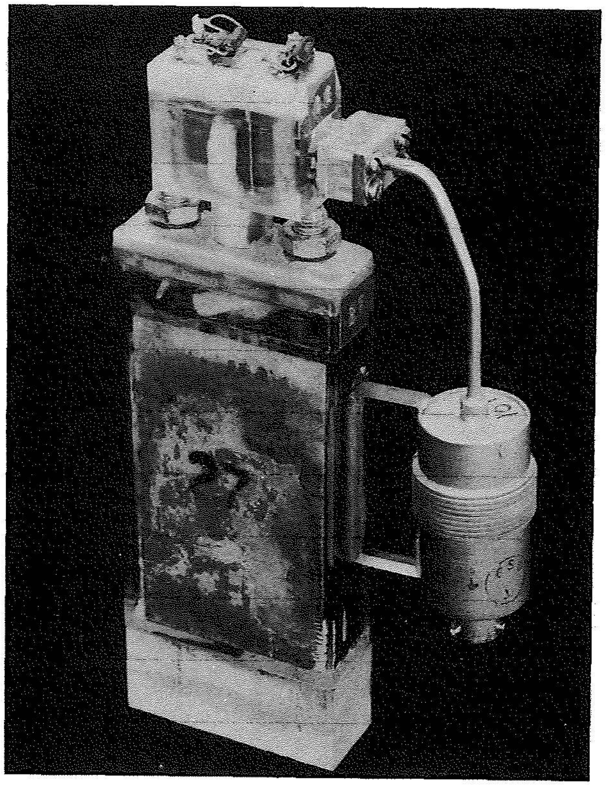


Figure 6. Microfuel Cell and Silver-Zinc Cell Used for Testing (Photo ES 23595)

Oxygen generated during the later stages of charge and during overcharge is the prime concern. If the oxygen can be consumed by the microfuel cell by electrochemical conversion of the oxygen to water, no battery internal pressure problem will result. The microfuel cell assembly also will recombine hydrogen gas, but the prime concern is for oxygen. After the partial pressure of water vapor equilibrates in all five cells, as well as in the gas manifold, microfuel cell, and auxiliary cell, there is no need to be concerned about individual cells drying out. There will be no further transfer of water vapor within the battery once this equilibrium condition is established.

The semipermeable membranes under consideration are:

1) Millipore – BDHP 02500
2) Chemplast – Zitex
3) Porex – POR-X
4) RAI – MPM
5) Polyethylene film

3.0 NEW TECHNOLOGY

Adaptation of the General Electric developed calcium hydroxide electrodeposition laboratory technique to a production technique permitting simultaneous coating of six silver plates may be considered new or improved technology. The use of an activation of the silver plate prior to electrodeposition of calcium hydroxide, rather than the use of charge/discharge cycling, is new technology. Both innovations used together produce greatly improved calcium hydroxide deposits in regard to uniform thickness, greater hardness, better adherence, and edge coating of the silver plates.

4.0 PROGRAM FOR NEXT REPORTING PERIOD

The Final Technical Report will be written at the conclusion of the next reporting period. The tasks planned during this next period are:

1) Completion of all battery package parts and internal components

2) Completion of battery assembly fabrication

3) Completion of the testing of two battery assemblies at Hughes

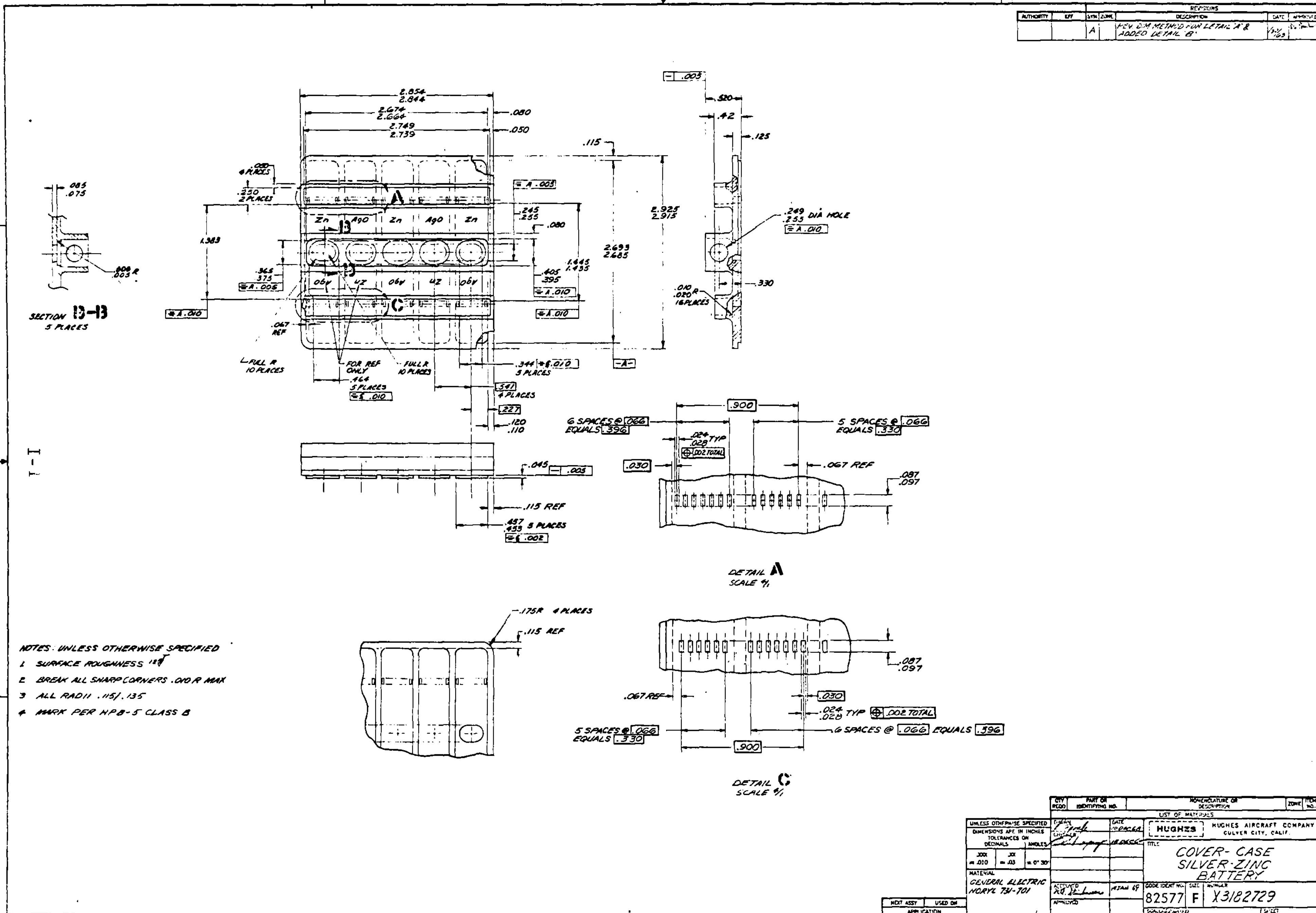
4) Shipment of all six batteries to NASA

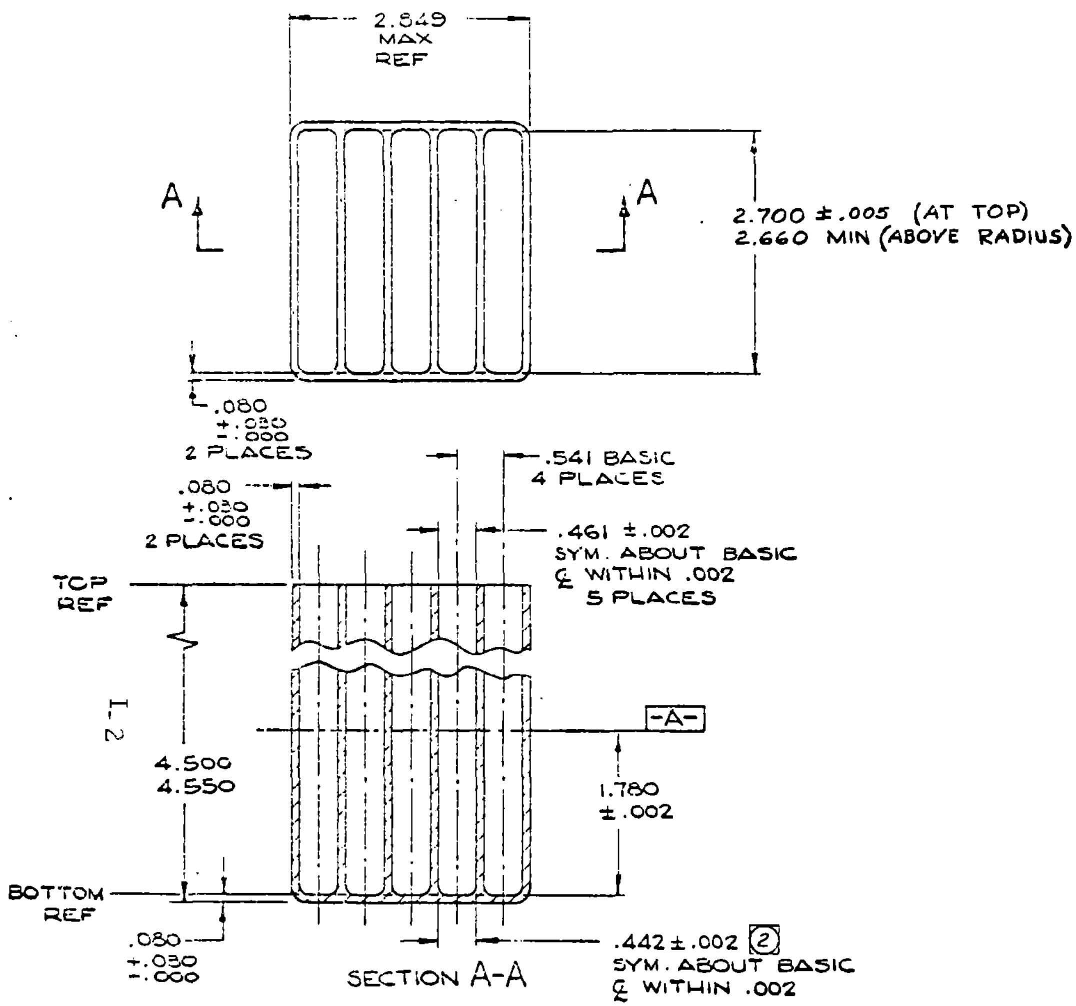
5.0 CONCLUSIONS AND RECOMMENDATIONS

It is difficult to draw any conclusions at this point in time without having completed the fabrication and testing of the batteries for this program. However, the battery design is complete and some comments should be made here. The battery design developed for this contract incorporates many separately developed improvements in the silver-zinc battery system, thereby adding to the design complexity. Because the batteries developed on this contract will be the test vehicle for evaluating the cumulative effect of all these separately developed improvements, the complex design is justifiable. Testing of these batteries by NASA and Hughes will determine the relative merit of this battery design, particularly with respect to cycle and wet stand life. Further, the test results should ascertain which single improvement, or combination of improvements, contributes to superior battery performance. The information then can be used to modify the present battery design for optimum performance.

If still more weight reduction is desired than has been achieved with the current battery package design, elimination of the injection molded case could be considered. The individual separator frames could be used for the battery case by means of a potting or encapsulation process following fabrication of the cell cores. This admittedly is a major step but not out of the question for space applications.

APPENDIX I. DRAWINGS


REVISIONS
A REV DIM METHOD FOR DETAIL 'A' & ADDED DETAIL 'B'
SECTION B-B
5 PLACES
DETAIL A
SCALE 4/1
DETAIL C
SCALE 4/1
.249 DIA HOLE
.253
FULL R 10 PLACES
FOR REF ONLY
6 SPACES @ .066 EQUALS .396
5 SPACES @ .066 EQUALS .330
.067 REF
.115 REF
.175R 4 PLACES
NOTES: UNLESS OTHERWISE SPECIFIED
1 SURFACE ROUGHNESS 125
2 BREAK ALL SHARP CORNERS .010 R MAX
3 ALL RADII .115/.135
4 MARK PER HPB-5 CLASS B
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
MATERIAL
GENERAL ELECTRIC NORYL 731-701
HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIF.
COVER-CASE
SILVER-ZINC
BATTERY
82577 F X3182729



SECTION A-A

NOTES: UNLESS OTHERWISE SPECIFIED

1. MAX DRAFT ANGLE 0°12' REF
2. THIS DIM TAKEN AT DATUM A
3. ALL INTERNAL RADII .090 ± .020
4. EDGE RADII .175 ± .020
5. SURFACE ROUGHNESS 63
6. IDENTIFY PER HP8-5, CLA, TYPE 5
7. ALL SURFACES TO BE FLAT WITHIN .005
8. MAX ALLOWABLE MISMATCH .010

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-6
XXX ±.010 XX ±.03 X ±.1 ANGLES ±0° 30'

MATERIAL
GENERAL ELECTRIC
NORYL-731-701

NEXT ASSY | USED ON
APPLICATION

DR Maguna — DATE 22 OCT 68
CHK — 2 DEC 68
APPD — 4 DEC 68

HUGHES
HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA

CASE, BATTERY —
SILVER-ZINC

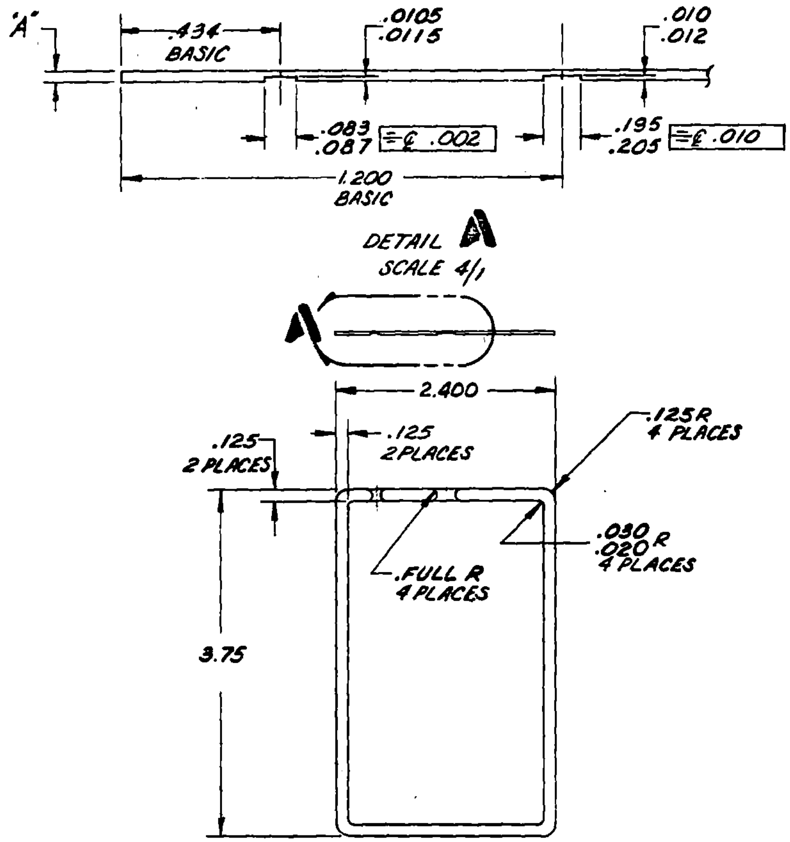
SIZE C | CODE IDENT NO. 82577 | X3182793
SCALE 1/1 | SHEET

NO. X3182793 REV

NO. X3182793

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

NO. X3182856 REV



NOTES — UNLESS OTHERWISE SPECIFIED
1. SURFACE ROUGHNESS 63√
2. IDENTIFY PER HP8-5, CL B.

DASH NO.	CONFIGURATION	DIM. A
-1	SHOWN	.022 .020
-2	OPPOSITE & NOTED	.030 .028

NO. X3182856 REV

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8
XXX ±.010 XX ±.03 X ±.1 ANGLES ±0° 30'

MATERIAL
GENERAL ELECTRIC NORYL 731-701

DR [signature] DATE 17 DEC 68
CHK [signature] 18 DEC 68
APPD [signature] 20 DEC 68

HUGHES — HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIFORNIA

FRAME, SEPARATOR — Ag-Zn BATTERY

SIZE C | CODE IDENT NO. 82577 | X3182856

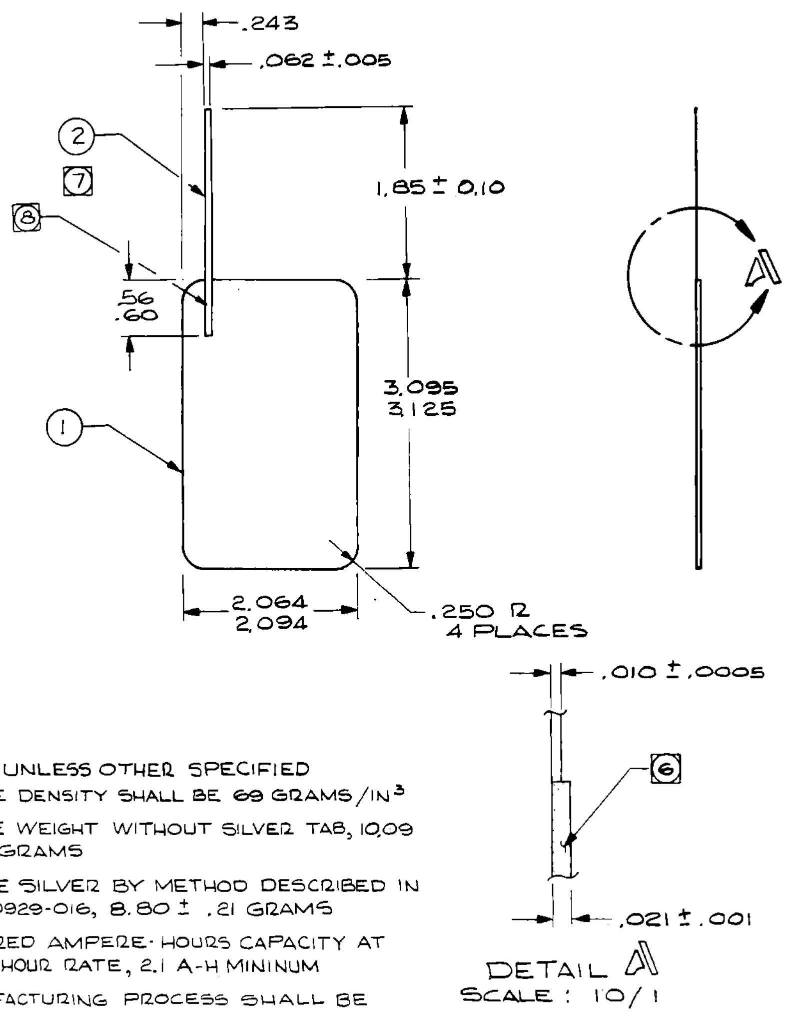
SCALE 1/1 & NOTED | SHEET

NEXT ASSY | USED ON
APPLICATION

FORM NO. 11064-CS-CC 1-65 OZALID 880-250

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

REV NO X3182870



I-4

NOTES – UNLESS OTHER SPECIFIED
1. PLATE DENSITY SHALL BE 69 GRAMS/IN^3
2. PLATE WEIGHT WITHOUT SILVER TAB, 10.09 ± .28 GRAMS
3. ACTIVE SILVER BY METHOD DESCRIBED IN XPS 30929-016, 8.80 ± .21 GRAMS
4. REQUIRED AMPERE-HOURS CAPACITY AT THE 1-HOUR RATE, 2.1 A-H MININUM
5. MANUFACTURING PROCESS SHALL BE ESB'S DP PROCESS.
6. 2/0 99.9% Ag EXPANDED GRID 0.200 gm/IN^2
7. TAB - 99.9% Ag
8. RESISTANCE WELD IN PLACE

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION		ZONE	ITEM NO.
1	-98	TAB	5 7		2
1	-99	PLATE	5		1

LIST OF MATERIALS

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8

.XXX	.XX	.X	ANGLES
±.010	±.03	±.1	±0° 30′

MATERIAL

		DATE
DR	DINO CALIVA	12-11-68
CHK	[signature]	12-13-68
APPD	[signature]	12-13-68

HUGHES

HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA

PLATE, SILVER –
2.2 A-H NOMINAL
CAPACITY UNFORMED

SIZE	CODE IDENT NO.	
C	82577	X3182870

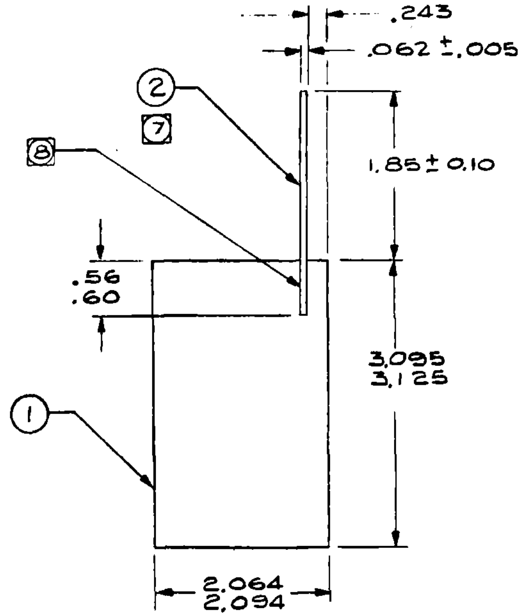
SCALE FULL SHEET 1 OF 1

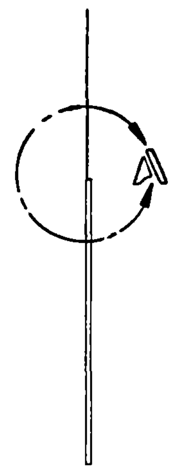
REV NO. X3182870

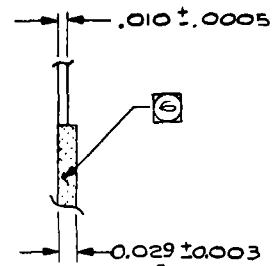
FORM NO. 11064-CS-CC 1-65 OZALID 880-250

EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED
			A	F/D DIM WAS .021 ± .001	1 JAN 69	

X 3182871 REV A







DETAIL A
SCALE 10/1

NOTES — UNLESS OTHERWISE SPECIFIED.

1. THE DENSITY OF ZnO SHALL BE 49.0 GRAMS/IN^3
2. ACTIVE MIX COMPOSITION ZnO 93%, HgO 2%, TEFLON 5%
3. PLATE WEIGHT WITHOUT SILVER TAB, 10.53 ± 0.10 GRAMS
4. ACTIVE MIX WEIGHT, 8.95 ± 0.05 GRAMS (ZnO 8.33 GRAMS)
5. PLATE TO BE MANUFACTURED BY ESB'S PROCESS A, DEVELOPED FOR JPL
6. 2/0 99.9% Ag EXPANDED GRID 0.200 gm/IN^2 TO COVER PLATE AREA WITH 1/4 INCH FOLD BACK AT EDGE
7. TAB - 99.9% Ag
8. RESISTANCE · WELD IN PLACE

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION		ZONE	ITEM NO.
1	-98	TAB	5 7		2
1	-99	PLATE	5 2		1

LIST OF MATERIALS

NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8
XXX ±.010 XX ±.03 X ±.1 ANGLES ±0° 30'
MATERIAL

		DATE
DR		12-11-63
CHK	H. Lu...	12-13-63
APPD		12-13-65

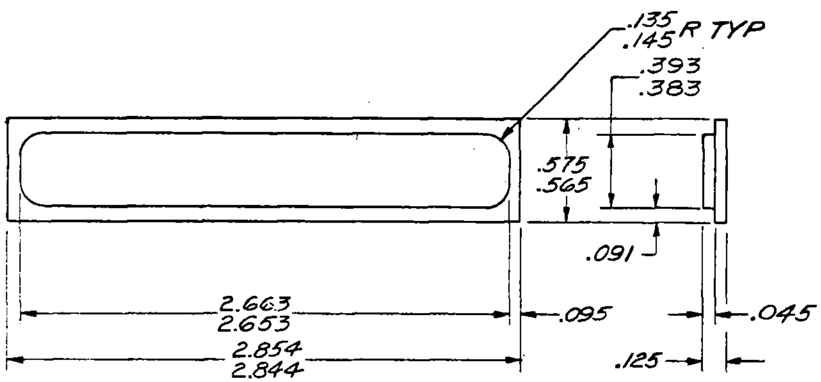
HUGHES — HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIFORNIA

PLATE, ZINC OXIDE— 5.5 A-H NOMINAL CAPACITY UNFORMED

SIZE C | CODE IDENT NO. 82577 | X 3182871

SCALE FULL | SHEET 1 OF 1

FORM NO. 11064-CS-CC 1-65 OZALID 880-250



NOTES:

1. BREAK ALL SHARP EDGES .010 R MAX.
2. SURFACE ROUGHNESS 125.
3. IDENTIFY PER HP 8-5, CLASS B.

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

NO. X3182883 REV

NO. X3182883 REV

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8
.XXX ±.010 .XX ±.03 .X ±.1 ANGLES ±0° 30'

MATERIAL
GENERAL ELECTRIC
NORYL 731-701

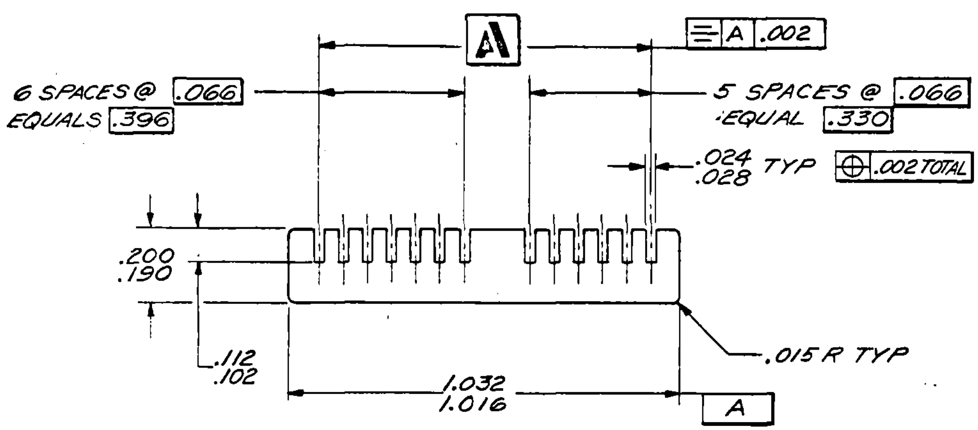
NEXT ASSY | USED ON
APPLICATION

DR A. Menegas DATE 1-10-62
CHK
APPD

HUGHES
HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA

COVER, FILL —
SILVER-ZINC
BATTERY

SIZE C CODE IDENT NO. 82577 X3182883
SCALE 2/1 SHEET



PART NUMBER	DIM A BASIC
-1	.900
-2	.909

NOTES

1. BREAK ALL SHARP EDGES .005 R MAX
2. SURFACE ROUGHNESS 125
3. IDENTIFY PER HP 8-5, CLASS B.

REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

NO. X3182884 REV

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8

.XXX	.XX	.X	ANGLES
±.010	±.03	±.1	±0° 30'

MATERIAL
.030 THK SHEET COPPER PER QQ-C-576, CR 1/2 HARD

NEXT ASSY | USED ON
APPLICATION

DR. A. Amegas DATE 1-10-69
CHK
APPD 4 FEB 69

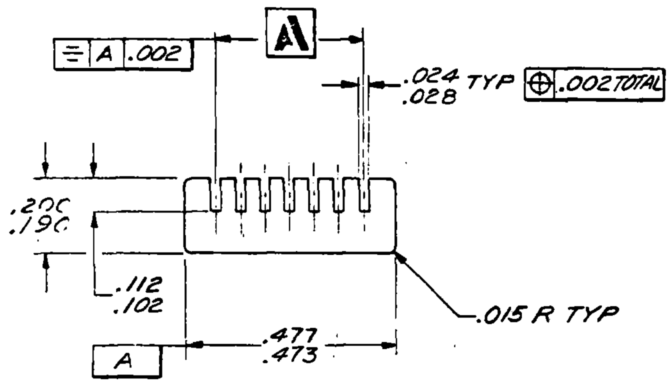
HUGHES
HUGHES AIRCRAFT COMPANY
CULVER CITY, CALIFORNIA

BUSS BAR — SILVER-ZINC BATTERY

SIZE C | CODE IDENT NO. 82577 | X3182884
SCALE 4/1 | SHEET

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED

REV NO. X3182885



PART NUMBER	DIM A
-1	6 SPACES @ .066 EQ .396
-2	5 SPACES @ .066 EQ .330

NOTES:

1. BREAK ALL SHARP EDGES .005 R MAX.
2. SURFACE ROUGHNESS 125
3. IDENTIFY PER HP 8-5, CLASS B.

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	ITEM NO.

LIST OF MATERIALS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES AND PER MIL-STD-8

.XXX ±.010 .XX ±.03 .X ±.1 ANGLES ±0° 30'

MATERIAL .030 THK SHEET COPPER PER QQ-C-576 CR 1/2 H

NEXT ASSY | USED ON

APPLICATION

DR [signature] DATE 1-13-69

CHK [signature] 31 Jan 69

APPD [signature] 4 FEB 69

HUGHES — HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIFORNIA

BUSS BAR, SHORT— SILVER-ZINC BATTERY

SIZE C CODE IDENT NO. 82577 X 3182885

SCALE 4/1 SHEET

FORM NO. 11064 CS CC 1-65 OZALID 880-250

APPENDIX II. SPECIFICATIONS

1.0 SCOPE

An unformed silver plate for aerospace application is covered within this specification.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

None.

STANDARDS

Military

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-454	Standard General Requirements for Electronic Equipment.
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment.

DRAWINGS

Hughes Aircraft Company

X3182870	Silver Plate, Unformed, 2.2 A-H Nominal Capacity

3.0 REQUIREMENTS

In general, a sintered, unformed, 2.2 A-H nominal capacity silver plate is required. This plate will be used in a high cycle life silver-zinc battery. The design goal for cycle life is 270 cycles with a 60% depth of discharge at the one hour rate. The charge rate will be in the range of 12 to 16 hours.

3.1 Physical Requirements. - Plates shall be in conformance to Hughes Drawing X3182870.

3.1.1 Plate Dimensions

Width	2.094 (+0.000, -0.030) inches
Height	3.125 (+0.000, -0.030) inches
Thickness	0.021 $\pm$ 0.001 inches
Corners	0.025 $\pm$ 0.010 inches typical maximum radius

3.1.2 Plate Weight

Active Silver 8.80 $\pm$ 0.21 grams.
Total Plate 10.09 $\pm$ 0.28 grams*.

*Active silver and grid, but not including connecting tab.

Plate weight will be controlled as follows:

Weigh grid in sheets sized to make six plates. Weigh 100% and reject outside of range $\bar{X} \pm 3\%$. Lot plot measured weights.

Sheet out DP. Two sheets shall be used for each six-plate sized biscuit. Weigh DP sheets 100%. Lot plot group into L, N, and H categories according to the following:

$L = \bar{X} - (3 \text{ to } 5\%)$

$N = \bar{X} \pm 3\%$

$H = \bar{X} + (3 \text{ to } 5\%)$

Make sandwiches using one grid and: two nominal DP sheets, or one H and one L DP sheets. Store as identical assemblies.

Sinter biscuits and die cut sintered blanks.

Weigh sintered blanks 100%. Lot plot group into L, N, and H groups using above categories. Reject all blanks outside range of $\bar{X} \pm 5\%$.

Spotweld ribbon to plate. Inspect for dimensions and weld integrity. Paint weld with epoxy and cure. Measure finished plate weight. Lot plot.

3.1.3 Plate Density. - The density of the silver plate shall be 69 grams/cubic inch.

3.1.4 Plate Electrical Connection. - A tab type of electrical connection is required. This tab shall extend from the top of the positive plate 1.85 $\pm$ 0.10 inches and shall be 0.062 $\pm$ 0.005 inches wide by 0.010 $\pm$ 0.0005" thick. The strip material used for this tab shall be 99.9 +% pure silver and shall be in the "full anneal" condition. The tab shall be attached to the silver Exmet-type grid of the positive plate utilizing localized coining of the plate and a capacitive spot weld. Evidence of optimum weld process conditons shall be available for review by Hughes personnel. The local weld area shall be coated with epoxy to inhibit any corrosion in this area during cell operation.

3.2 Chemical Requirements

3.2.1 Silver Powder. - The silver powder used for positive electrodes shall be 99.9% pure silver, with no single metallic or non-metallic impurity exceeding 500 ppm.

3.2.2 Grid. - The silver Exmet-type grid used in positive electrodes shall be 99.9% pure silver, with no single metallic or non-metallic impurity exceeding 500 ppm.

3.3 Electrical Requirements

3.3.1 Capacity. - Individual positive plates shall deliver a minimum capacity of 2.10 ampere-hours when discharged at the one hour rate at 25°C. Prior to discharge, positive plates shall be charged at 25°C by constant current charge at 6.5 ma/in^2 to 1.98 volts with respect to a pair of zinc plates. Charge and discharge shall be performed against two zinc plates, each equal in area to the silver plate. The ampere-hour capacity of the pair of zinc plates shall exceed the silver plate's capacity by at least 50%.

3.3.2 Current Density. - The plate specified herein must operate at the following design points:

1) Charge 6. to 10. ma/in^2
2) Discharge 60. to 100. ma/in^2

3.4 Quality Requirements

3.4.1 Inspection. - All non-destructively determined variables shall be measured on a 100% sampling basis. The following variables shall be measured:

Plate thickness, height, width.

Grid weight for six plate assembly.

Sintered plate blank weight.

Computed active material weight based upon the measured mean grid weight for each six-plate biscuit group.

Refer to Section 3.1.2 for further description of measurements required.

Individual plate identifications need not be maintained; however, a frequency distribution plot, or equivalent tabular statistical information, shall be submitted for all variables measured. Evidence, of rejection of plates falling outside the tolerance limits for any variable, shall be provided by the supplier to Hughes.

3.4.2 Manufacturing Lot. - All positive plates supplied shall be fabricated from only one lot of active material. One mix batch of silver powder and one lot of resin will constitute one lot of active material. Documentation shall be available for review by Hughes to attest that only one active material mix batch is used. Copies of this documentation shall be sent to Hughes upon request.

3.5 Environmental Requirements

3.5.1 Operating Temperature Range. - The positive plates shall be designed and fabricated for optimum performance within the temperature range of 30 to 100°F.

3.5.2 Electrolyte. - Plates shall be manufactured for optimum performance in 40 wt.% KOH solution.

4.0 TESTS

4.1 Physical

4.1.1 Dimensions. - All plate dimensions, particularly thickness, height, and width shall be measured on a 100% sampling basis to show conformance to Paragraph 3.1.1 and Hughes Drawing X3182870. Measurement data shall be recorded and presented to Hughes in either tabular form or in the form of a frequency distribution curve for each dimension measured.

4.1.2 Weight. - Exmet-type grids and completed plates shall be weighed and the data recorded to demonstrate conformance to Paragraph 3.1.2. Weights shall be determined by 100% sampling with the data submitted to Hughes as described in Paragraph 4.1.1.

4.2 Chemical

4.2.1 Silver Powder. - A receiving inspection lot analysis record will suffice to demonstrate conformance to Paragraph 3.2.1. A certificate of conformance will be acceptable only if traceability to the material supplier's analytical records can be established.

4.2.2 Grid. - A receiving inspection lot analysis record will suffice to demonstrate conformance to Paragraph 3.2.1. A certificate of conformance will be acceptable only if traceability to the material supplier's analytical records can be established.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging. - Thirty-two plates shall be stacked together with two similarly sized pieces of 0.075" to 0.100" cardboard on each end of the stack. Adhesive coated glass tape shall be wrapped around the outside of this sandwich, at least two wraps in separate places in the 2.1" widthwise direction and one wrap in the 3.1" height direction. Glass taped, cardboard-plate sandwiches shall then be placed into wooden shipping containers. Not more than one-third of the total number of plates ordered shall be placed into any one wooden shipping container.

5.2 Identification. - Each shipping container shall be externally identified with the following information:

a) Hughes Part Number (Specification and Drawing Number)
b) Seller's Part Number
c) Date of Completion of Manufacture.
d) Manufacturing Lot Number
e) Hughes Purchase Order Number.

5.3 Information Label. - In a conspicuous location near the address label, the following information shall be plainly visible on the shipping container:

Attention: Hughes Aircraft Company
Receiving and Receiving Inspection Departments

This box contains fragile battery plates. Do not open without first contacting Hughes Buyer and/or Responsible Engineer. Refer to HAC PO Number shown externally on this box.

6.0 QUALITY ASSURANCE PROVISIONS

6.1 General. - The materials, processes and assembly techniques used to fabricate the hardware covered by this specification shall be subject to extensive inspection and testing by both the Seller and Hughes Aircraft Company. Surveyor Project inspection procedures will be the model for the QA plan for this program.

6.2 Inspection

6.2.1 Seller Inspection. - Product quality assurance shall be provided by the Seller by a series of in-process inspections commencing with receipt of raw materials, and parts and continuing through the finished product. The selected inspection points shall have the approval of HAC. A record shall be maintained of all inspections and be subject to review by HAC. A process flow logic chart shall be supplied to Hughes Aircraft Company detailing each process step and inspection procedure.

6.2.2 HAC Source Inspection. - The Hughes Aircraft Company shall at its option provide inspection to adequately monitor the Seller's quality control effort including in-process inspection and in-process tests. The complete hardware may be source inspected by HAC to assure that the product conforms to all the requirements specified on the applicable drawings and specifications and may include witnessing of acceptance tests.

6.2.3 Rejected Assemblies. - Rejected assemblies shall not be resubmitted for approval without furnishing full particulars concerning the rejection, the measure taken to overcome the defects, and the prevention of their future occurrence. Each rejected assembly shall be identified by a serialized rejection tag. This rejection tag shall not be removed until rework requirements have been complied with, and the tag shall be removed only by, or in the presence of, an authorized representative of HAC.

1.0 SCOPE

An unformed zinc oxide plate for aerospace application is covered within this specification.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

Specifications

Military

None.

Standards

Military

MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts.
MIL-STD-454	Standard General Requirements for Electronic Equipment.
MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment.

Drawings

Hughes Aircraft Company

X3182871	Zinc Oxide Plate - Unformed, 5.5 A-H Capacity.

3.0 REQUIREMENTS

In general, a teflonated, dry, unformed, 5.5 A-H zinc oxide plate is required for use in a 12 A-H nominal capacity silver-zinc cell. This cell will consist of six positive and seven negative plates.

3.1 Physical Requirements. - Plates shall be in conformance with Hughes Drawing X3182871.

3.1.1 Plate Dimensions

Width	2.094 ± 0.030 inches
Height	3.125 ± 0.030 inches
Thickness	0.029 ± 0.003 inches
Corners	Square

3.1.2 Plate Weight and Composition

Zinc Oxide, 93%	8.33 grams
Teflon Powder, 5%	0.45
Mercuric Oxide, 2%	0.17
Total Active Mix, 100%	8.95 $\pm$ 0.18 grams
2/0 Ag Expanded Grid (with ¼" foldback at edges)	1.58 $\pm$ 0.08
Ag Tab	0.26 $\pm$ 0.05
Finished Plate Weight	10.79 $\pm$ 0.31 grams

Plate manufacturer will inspect plates 100% and lot plot each of the following weights:

Grid weights
Core Structure (i.e., grid and tab)
Finished Plate

Plates must be identified in three groups according to weight:

$L = \overline{X} - (3 \text{ to } 5\%)$

$N = \overline{X} \pm 3\%$

$H = \overline{X} + (3 \text{ to } 5\%)$

3.1.3 Density. - The density of ZnO shall be 49 grams per cubic inch.

3.1.4 Plate Electrical Connection. - A tab type of electrical connection is required. This tab shall extend from the top of the negative plate 1.85 $\pm$ 0.10 inches and shall be 0.062 $\pm$ 0.005 inches wide by 0.010 $\pm$ 0.0005 inches thick. The strip material used for this tab shall be 99.9+% pure silver and shall be in the "full anneal" condition. The tab shall be attached to the silver Exmet-type grid of the negative plate utilizing localized coining of the plate and a capacitive spot weld. Evidence of optimum weld process conditions shall be available for review by Hughes personnel.

3.1.5 Exmet-Type Grid. - The supporting structure of the negative plate shall be a 2/0, 99.9% silver, pierced and expanded, 0.200 $\pm$ 0.010 grams per square inch, Exmet-type grid. The grid shall be 2.094 inches by 3.125 inches with the addition of a 0.25 inch foldback at the edges.

3.2 Chemical Requirements

3.2.1 Zinc Oxide Powder. - The zinc oxide powder shall be equivalent to A.C.S. reagent grade in purity. Particle size shall be such that this powder has been thoroughly tested in the battery manufacturer's normal acceptance procedures, which shall include evidence of successful operation of silver-zinc cells manufactured from this powder. This evidence, in the form of engineering or quality control records, shall be made available to Hughes personnel upon request.

3.2.2 Mercuric Oxide. - The mercuric oxide used in the negative plate shall be A.C.S. reagent grade purity. It shall be used to make up 2% of the total active mix weight.

3.2.3 Teflon Powder. - Teflon 7 powder shall be used following a controlled reduction in particle size at liquid nitrogen temperature. Plate supplier must furnish evidence of:

a) In-process controls for the grinding process.

b) The mean particle size and particle size distribution.

c) The variables being within optimum limits for plate manufacture.

3.2.4 Exmet-Type Grid. - The silver Exmet-type grid used in negative electrodes shall be 99.9+% silver, with no single metallic or non-metallic impurity exceeding 500 ppm.

3.3 Electrical Requirements

3.3.1 Capacity. - Individual negative plates shall deliver a minimum capacity of 4.4 A-H when discharged at the one hour rate at 25°C. Prior ot discharge, negative plates shall be charged at 25°C by constant current at C/20 or 6.6 ma/in^2 for 21 hours.

3.3.2 Current Density. - The plate specified herein must operate at the following design points:

a)	Charge	6.0 to 10.0 ma/in^2
b)	Discharge	60 to 100 ma/in^2

3.3.3 Depth of Discharge. - The battery into which the plates of this specification will be incorporated, will operate between a 40 and 60% depth of discharge. The discharge current density figures of 3.3.2 reflect this DOD.

3.4 Quality Requirements

3.4.1 Inspection. - All non-destructively determined variables shall be measured on a 100% sa. ling basis. The following variables shall be measured:

a) Plate thickness, height and width.
b) Exmet-type grid weight.
c) Total plate weight.
d) Active mix weight, by difference.

Individual plate identifications need not be maintained; however, a frequency distribution plot, or equivalent tabular statistical information, shall be submitted for all variables measured. Evidence of rejection of plates falling outside the tolerance limits for any variable, shall be provided by the supplier to Hughes.

3.4.2 Manufacturing Lot. - All negative plates supplied shall be fabricated from not more than three mix batches of active material. Documentation shall be available for review by Hughes to attest that not more than three active material mix batches are used. Copies of this documentation shall be sent to Hughes upon request.

3.5 Environmental Requirements

3.5.1 Operating Temperature Range. - The negative plates shall be designed and fabricated for optimum performance within the temperature range of 30 to 100°F.

3.5.2 Electrolyte. - Plates shall be manufactured for optimum performance in 40 wt. % KOH solution.

4.0 TESTS

4.1 Physical

4.1.1 Dimensions. - All plate dimensions, particularly thickness, height, and width shall be measured on a 100% sampling basis to show conformance to Paragraph 3.1.1 and Hughes Drawing X3182871. Measurement data shall be recorded and presented to Hughes in either tabular form or in the form of a frequency distribution curve for each dimension measured.

4.1.2 Weight. - Exmet-type grids and completed plates shall be weighed and the data recorded to demonstrate conformance to Paragraph 3.1.2. Weights shall be determined by 100% sampling with the data submitted to Hughes as described in Paragraph 4.1.1.

4.2 Chemical

4.2.1 Zinc Oxide. - A receiving inspection lot analysis record will suffice to demonstrate conformance to Paragraph 3.2.1. A certificate of conformance will be acceptable only if traceability to the material supplier's analytical records can be established.

4 2.2 Mercuric Oxide. - A receiving inspection lot analysis record will suffice to demonstrate conformance to Paragraph 3.2.2. A certificate of conformance will be acceptable only if traceability to the material supplier's analytical records can be established

4.2.3 Grid. - A receiving inspection lot analysis record will suffice to demonstrate conformance to Paragraph 3.2.4. A certificate of conformance will be acceptable only if traceability to the material supplier's analytical records can be established.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging . - Four plates shall be stacked together with pieces of cardboard 0.075 to 0.100" thick interleaved between plates, with one piece of cardboard over each outer plate in the stack. The width and height of the cardboard shall be equivalent or slightly larger than that of the plates. The plate-cardboard sandwich shall be wrapped with adhesive coated glass tape, two wraps widthwise, one wrap heightwise. Plates shall be positioned in the shipping container such that they ride on edge rather than flat. Zinc plates shall be shipped with the Viskon retainer intact.

5.2 Identification. - Each shipping container shall be externally identified with the following information:

a) Hughes Part Number (Specification and Drawing Number).
b) Seller's Part Number.
c) Date of Completion of Manufacture.
d) Manufacturing Lot Number.
e) Hughes Purchase Order Number.

5.3 Information Label. - In a conspicuous location near the address label, the following information shall be plainly visible on the shipping container:

Attention: Hughes Aircraft Company
Receiving and Receiving Inspection Departments

This box contains fragile battery plates. Do not open without first contacting Hughes Buyer and/or Responsible Engineer. Refer to HAC PO Number shown externally on this box.

6.0 QUALITY ASSURANCE PROVISIONS

6.1 General. - The materials, processes and assembly techniques used to fabricate the hardware covered by this specification shall be subject to extensive inspection and testing by both the Seller and Hughes Aircraft Company.

6.2 Inspection

6.2.1 Seller Inspection. - Product quality assurance shall be provided by the Seller by a series of in-process inspections commencing with receipt of raw materials, and parts and continuing through the finished product. The selected inspection points shall have the approval of HAC. A record shall be maintained of all inspections and be subject to review by HAC.

6.2.2 HAC Source Inspection. - The Hughes Aircraft Company shall at its option provide inspection to adequately monitor the Seller's quality control effort including in-process inspection and in-process tests. The complete hardware may be source inspected by HAC to assure that the product conforms to all the requirements specified on the applicable drawings and specifications and may include witnessing of acceptance tests.

6.2.3 Rejected Assemblies. - Rejected assemblies shall not be resubmitted for approval without furnishing full particulars concerning the rejection, the measure taken to overcome the defects, and the prevention of their future occurrence. Each rejected assembly shall be identified by a serialized rejection tag. This rejection tag shall not be removed until rework requirements have been complied with, and the tag shall be removed only by, or in the presence of, an authorized representative of HAC.

7.0 INFORMATION

7.1 Exclusion of Viskon Absorber. - Because the plate specified herein utilizes teflon fibers, no Viskon absorber is necessary. Any protective covering applied to the zinc plate shall be readily removable without detrimental effect upon the plate.